AMERICAN MUSEUM OF NATURAL HISTORY

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CHEETAHS' INNER EAR IS ONE-OF-A-KIND, VITAL TO HIGH-SPEED HUNTING

STUDY FINDS THAT THE DISTINCT VESTIBULAR SYSTEM OF THE WORLD'S FASTEST LAND ANIMAL ONLY EVOLVED RECENTLY

The world's fastest land animal, the cheetah, is a successful hunter not only because it is quick, but also because it can hold an incredibly still gaze while pursuing prey. For the first time, researchers have investigated the cheetah's extraordinary sensory abilities by analyzing the speedy animal's inner ear, an organ that is essential for maintaining body balance and adapting head posture during movement in most vertebrates. The study, published today in the journal *Scientific Reports* and led by researchers at the American Museum of Natural History, finds that the inner ear of modern cheetahs is unique and likely evolved relatively recently.

"If you watch a cheetah run in slow motion, you'll see incredible feats of movement: its legs, its back, its muscles all move with such coordinated power. But its head hardly moves at all," said lead author Camille Grohé, who conducted this work during a National Science Foundation and Frick Postdoctoral Fellowship in the Museum's Division of Paleontology. "The inner ear facilitates the cheetah's remarkable ability to maintain visual and postural stability while running and capturing prey at speeds of up to 65 miles per hour. Until now, no one has investigated the inner ear's role in this incredible hunting specialization."

In the inner ear of vertebrates, the balance system consists of three semicircular canals that contain fluid and sensory hair cells that detect movement of the head. Each of

the semicircular canals is positioned at a different angle and is especially sensitive to different movements: up and down, side-to-side, and tilting from one side to the other.

The researchers used high-resolution X-ray computed tomography (CT) at the Museum's Microscopy and Imaging Facility, the National Museum of Natural History in Paris, and the Biomaterials Science Center of the University of Basel in Switzerland to scan the skulls of 21 felid specimens, including seven modern cheetahs (*Acinonyx jubatus*) from distinct populations, a closely related extinct cheetah (*Acinonyx pardinensis*) that lived in the Pleistocene between about 2.6 million and 126,000 years ago, and more than a dozen other living felid species. With those data, they created detailed 3-D virtual images of each species' inner ear shape and dimensions.

They found that the inner ears of living cheetahs differ markedly from those of all other felids alive today, with a greater overall volume of the vestibular system and longer anterior and posterior semicircular canals.

"This distinctive inner ear anatomy reflects enhanced sensitivity and more rapid responses to head motions, explaining the cheetah's extraordinary ability to maintain visual stability and to keep their gaze locked in on prey even during incredibly high-speed hunting," said coauthor John Flynn, the Frick Curator of Fossil Mammals in the Museum's Division of Paleontology.

These traits were not present in *Acinonyx pardinensis*, the extinct species examined by the researchers, emphasizing the recent evolution of the highly specialized inner ear of modern cheetah.

"By using high-tech equipment to look deep inside the skulls of modern and fossil cat species, we have discovered that there was a decoupling of locomotor and sensory system adaptations to high-speed predation in the cheetah lineage ," Grohé said. "The competition with other predators, notably large pantherines and sabertooth cats, has probably constrained the cheetah to evolve a high-speed hunting strategy. The living cheetah's ancestors have evolved slender bones that would allow them to run very fast and

then an inner ear ultra sensitive to head movements to hold their head still, enabling them to run even faster."

The third author on this study, Beatrice Lee, was a high school intern at the Museum from the Bergen County Academies of Hackensack, New Jersey, when she assisted Grohé and Flynn with the data acquisition of this research. She is now a student at Middlebury College in Vermont.

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The authors dedicate this work to the late Stéphane Peigné (National Museum of Natural History in Paris) for his contributions to carnivore evolution and, notably, his revision of the systematics of *Proailurus*, another fossil cat examined in this study.

Scientific Reports paper: www.nature.com/articles/s41598-018-20198-3

AMERICAN MUSEUM OF NATURAL HISTORY (AMNH.ORG)

The American Museum of Natural History, founded in 1869, is one of the world's preeminent scientific, educational, and cultural institutions. The Museum encompasses 45 permanent exhibition halls, including those in the Rose Center for Earth and Space and the Hayden Planetarium, as well as galleries for temporary exhibitions. It is home to the Theodore Roosevelt Memorial, New York State's official memorial to its 33rd governor and the nation's 26th president, and a tribute to Roosevelt's enduring legacy of conservation. The Museum's five active research divisions and three cross-disciplinary centers support approximately 200 scientists, whose work draws on a world-class permanent collection of more than 34 million specimens and artifacts, as well as specialized collections for frozen tissue and genomic and astrophysical data, and one of the largest natural history libraries in the world. Through its Richard Gilder Graduate School, it is the only American museum authorized to grant the Ph.D. degree. Beginning in 2015, the Richard Gilder Graduate School also began granting the Master of Arts in Teaching (MAT) degree, the only such

freestanding museum program. Annual visitation has grown to approximately 5 million, and the Museum's exhibitions and Space Shows are seen by millions more in venues on six continents. The Museum's website, mobile apps, and MOOCs (massive open online courses) extend its scientific research and collections, exhibitions, and educational programs to additional audiences around the globe. Visit **amnh.org** for more information.

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